

ORIGINAL ARTICLE

Cervical muscle strength measurement in two groups of elite Greco-Roman and free style wrestlers and a group of non-athletic subjects

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Background: Free style and Greco-Roman are two types of wrestling.

Objectives: The aim of this study was to examine the maximal isometric strength of cervical extension (ISCE) and the maximal isometric strength of cervical flexion (ISCF) in two groups of elite wrestlers and a group of non-athletic subjects.

Methods: Fourteen elite Greco-Roman wrestlers (aged 19–25 years), 16 elite free style wrestlers (aged 18–25 years), and 16 non-athletic subjects (aged 18–25 years) participated in this study. All wrestlers competed at international level with the Iranian national team. Maximum voluntary contractions (MVC) of cervical extensor and flexor muscles were measured using a custom made device. The ratios of ISCE to weight (ISCE/weight), ISCF to weight (ISCF/weight), and ISCF to ISCE (ISCF/ISCE) were calculated for group comparisons. Pearson product moment test was used to estimate correlation between maximal isometric strength measurements and anthropometric variables. A one way analysis of variance was computed to compare ISCE/weight, ISCF/weight, and ISCF/ISCE among groups.

Results: There was significant correlation between maximum cervical extension and flexion strengths and weight in all groups ($p < 0.05$, $n = 46$). The ratios of cervical muscle strengths to weight were significantly higher in wrestlers than in non-athletic subjects ($p < 0.00$). Greco-Roman wrestlers appeared to be stronger than free style wrestlers following comparison of all ratios.

Conclusions: Neck muscle force measurements may be a useful test for athletes in combat sports like wrestling. They can be applied to identify the weakness of a group of muscles in the neck area and to devise a proper training program.

Of the various anatomical structures, the cervical muscles and ligamentous structures are very susceptible to injury particularly in sports such as wrestling, football, and ice hockey.^{1–3} Sports related cervical injuries may be sustained when an applied passive force reaches close to or exceeds the normal limit of spinal muscle power. As a result, the muscles or ligaments may be overloaded and over-stretched, producing pain and muscle spasm.

More muscle tension is produced by eccentric muscle contraction than by concentric muscle contraction, making the muscle more susceptible to injury. In sports activities such as wrestling, wrestlers are required to withstand massive loads to maintain their acquired position, and this involves intensive isometric contraction of cervical muscles. For instance, they may need to maintain the spinal curve in an arched position for a period of time.⁴ This means that wrestlers need strong cervical extensor muscles in order to counter their opponent's motion (that is, forceful eccentric contraction). Wrestlers are at a high risk of injuries to structures such as the neck arising from overload or excessive training.⁵ In the limited data available on cervical injuries in athletes, the risk of wrestlers sustaining a neck injury has been reported to be 20% for a first injury during the first year of practice and about 50% for subsequent years.¹ These high etiological risk factors suggest that research on the cervical muscles may be of substantial value to wrestlers.

Wrestling styles include free style and Greco-Roman. In Greco-Roman wrestling holds are forbidden below the waist, but in free style wrestling they are allowed.⁴ In most cases, cervical injuries occur when the defender tries but fails to keep the head and neck in a fixed position against the opponent's force. Neck hyperflexion occurs when a wrestler

is caught in a roll position. Severe neck lateral bending occurs when a wrestler tries to pull his opponent's leg towards him; the attacking wrestler places his neck in flexion. The wrestler has to keep the cervical spine in hyperextension, while the opponent is forcing the shoulders towards the mat. In all these cases soft tissues including muscles, tendons, ligaments, joint capsules, and discs will be passively stretched. If muscle cannot withstand the eccentric force, connective tissue lesions may occur. Degenerative changes may also occur due to repetitive injury to the same structures.

This study aimed to evaluate and compare the strength of cervical muscle force in elite wrestlers with that of non-athletic subjects. In this study, the ratio of cervical extension strength to weight, the ratio of cervical flexion strength to weight, and the ratio of cervical flexion strength to cervical extension strength were compared between wrestlers and non-athletes.

METHODS

A total of 46 subjects including 14 elite Greco-Roman wrestlers (aged 19–25 years), 16 elite free style wrestlers (aged 18–25 years), and 16 non-athletic subjects (aged 18–25 years) voluntarily participated in this study. All wrestlers were members of the Iranian national wrestling team. The descriptive characteristics of all of the subjects are presented in table 1. The Greco-Roman and free style wrestlers had all participated in national and international competitions for a minimum of 4 years. The subjects of the non-athletic group

Abbreviations: ISCE, isometric strength of cervical extension; ISCF, isometric strength of cervical flexion; MVC, maximum voluntary contractions

Table 1 Weight, height, and BMI in Greco-Roman wrestlers, free style wrestlers, and non-athletic controls (n=46)

Group	n	Age	Weight (kg)	Height (m)	BMI (kg/m ²)
Greco-Roman wrestlers	14	20.5 (1.8), 19.0–25.0	75.3 (19.7), 54.0–127.0	1.73 (0.98), 1.61–1.95	24.5 (3.7), 20.8–33.4
Free style wrestlers	16	21.1 (2.3), 18.0–25.0	76.9 (10.8), 61.0–95.0	1.75 (0.69), 1.61–1.85	24.8 (1.9), 21.6–27.8
Non-athletic subjects	16	21.2 (1.5), 18.0–25.0	74.1 (10.8), 60.0–96.0	1.74 (0.55), 1.63–1.88	24.4 (3.7), 19.8–31.5

BMI (body mass index)=weight/height². Values are presented as mean (SD), range.

habitually trained with no concentration on the neck and shoulder areas.

All the procedures in this study were approved by the Ethical Committee of the Shaheed Beheshti University of Medical Sciences and Health Services, Tehran, Iran. The subjects gave their informed consent prior to the examination and also filled in a questionnaire on their physical activities and medical history. All subjects underwent a medical and physical examination.

The results of the medical history questionnaire and the physical examination indicated that three of the wrestlers had a positive background of traumatic injury to the neck area, and 14 of the wrestlers had been referred to a physician for medical care because of cervical disorders.

As neck pain is common during intensive muscular training, only seven of the wrestlers were completely pain free. However, although some wrestlers reported neck pain, it did not restrict their training and participation in competitions. Thus, all wrestlers were considered fit to compete at the time of examination.

Isometric cervical muscle force measurement

A custom designed isometric measurement device was used to test isometric neck muscle strength in different directions of flexion and extension. A physiotherapist with good experience in neck muscle strength testing recorded all the measurements. The methodology followed a standardised testing method.⁶ Briefly, to measure cervical extension strength, the cell load was against the occipital bone and for cervical flexion force measurement it was against the

frontal area (fig 1). In all strength measurements subjects were in a sitting position, both hands were on the thigh with the arms close to the body, both hips were in adduction and 90° flexion, both knees were in 90° flexion, and both feet were on the floor. The sternal notch, chin, and tip of the nose were kept in a vertical line and the line between the base of the nose and occiput were kept horizontal. The seat surface was horizontal. The thorax and the pelvis were tightly held by two straps at the level of the scapula and the iliac spine. In order to warm up, subjects performed three sub-maximal cervical muscle contractions before each set of maximal voluntary contractions (MVCs). The subjects were instructed to relax their trunk, upper limbs, and lower limbs. Then, they were instructed to perform three MVCs in each direction. The MVCs each lasted for 3–4 s and were separated by 5 min intervals. The order of testing was similar for all subjects: first the isometric strength of cervical extension (ISCE) was measured and then isometric strength of cervical flexion (ISCF).

STATISTICS

The mean(SD) and range of the anthropometric variables, the ISCE, the ISCF, the ratios of the ISCE and ISCF to weight, and the ratio of ISCF to ISCE in different groups of subjects were recorded. The correlation between the ISCF and ISCE and the correlation between the isometric neck muscle forces and anthropometric variables were computed by Pearson's product moment. A one way analysis of variance was computed to compare the ISCE to weight, the ISCF to weight, and the ISCF/ISCE between athletes and non-athletes and between wrestlers with neck pain and wrestlers without neck pain.

RESULTS

There were no statistically significant differences in age, weight, or height among the Greco-Roman wrestlers, the free style wrestlers, and the non-athletic subjects.

The mean (SD) of maximum isometric neck strength, its ratio to body weight, and the relationship between flexor and extensor forces in wrestlers and controls are presented in table 2. Wrestlers and the non-athletes differed significantly as regards all measured indices of force ($p<0.00$). There were no significant differences in ISCF and ISCE between Greco-Roman and free style wrestlers. The forces per kilogram body weight towards the tested directions were significantly greater in wrestlers than in non-athletes ($p<0.05$).

While analysing all groups together (three groups, 46 subjects), isometric cervical extension strength correlated significantly with isometric cervical flexion strength ($r=0.66$, $p<0.001$). There was also a weak correlation between ISCE and weight ($r=0.30$, $p<0.05$) and between ISCF and weight ($r=0.33$, $p<0.05$).

DISCUSSION

Wrestlers use a variety of individual professional techniques to achieve a win (a fall). A fall is the act of forcing the opponent's shoulder to the mat for a prescribe period of time during which the opponent is held in an arched position. In this manoeuvre the pressure is exerted both by the offensive wrestler and his own weight. Neck muscles required to



Figure 1 Subject's position during muscle strength measurement. (Photograph reproduced with permission)

Table 2 Cervical flexion and extension strength, cervical flexion and extension strength per kilogram body weight, and the ratio of cervical flexion strength to cervical extension strength in each group of athletes and non-athletes

Group	n	Extension (N)	Flexion (N)	Ext./weight (N/kg)	Flex./weight (N/kg)	Flex./Ext. (N)
Greco-Roman wrestlers	14	422.9 (86.9), 310.0–608.2	276.9 (52.9), 161.9–397.2	5.7 (0.9), 3.8–6.7	3.8 (0.7), 2.2–4.5	0.7 (0.1), 0.5–0.9
Free style wrestlers	16	368.2 (69.0), 286.4–522.8	261.2 (54.3), 169.7–353.2	4.8 (0.7), 2.2–5.8	3.4 (0.8), 2.2–4.8	0.7 (0.1), 0.4–0.9
Non-athletic subjects	16	302.4 (63.8)*, 206.0–402.2	144.4 (45.3)*, 96.1–253.1	4.1 (1.0)*, 2.2–5.5	1.9 (0.5)*, 1.2–2.8	0.5 (0.1), 0.3–0.5

*Significant level ($p < 0.05$).

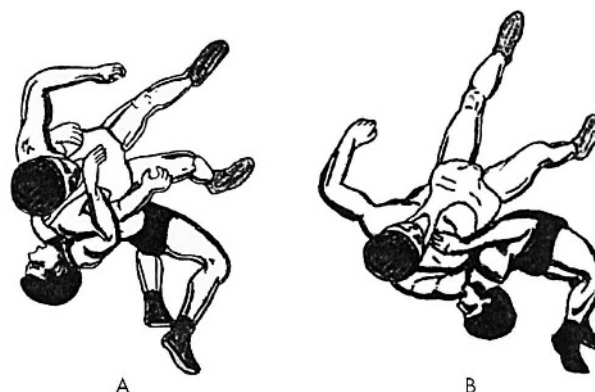
Values are presented as mean (SD), range. Ext., extension; Flex., flexion; NS, non significant.

maintain or hold the cervical and spinal arc at a fall are relatively more powerful in wrestlers than in other athletes.^{7,8} However, cervical injuries are very common in wrestling.^{9–11} Repetitive pulling and pushing, controlling take down, and maintaining or resisting the arch position may lead to strain or sprain injuries in the cervical area. Thus, wrestlers may have a high risk of neck injury despite having strong cervical muscle strength.^{12–14} Most injuries are minor, but weak neck muscles pose a considerable risk for severe neck injuries.

In this study, we measured and compared the maximal isometric strength of cervical extensor and flexor muscles in a group of Greco-Roman and free style wrestlers and a group of non-athletic subjects. The strength of the cervical muscles was measured by an isometric apparatus since isometric muscle force measurement has been shown to be a good indicator to compare the level of muscle performance between groups.^{15–17}

In this study, we followed a reliable method to measure the strength of cervical muscles as reported in our earlier study.⁶ The subject's head and neck were kept in a neutral position. In most of the studies measuring the strength of neck muscles, the level of the fulcrum and the position of the subjects have either not been reported or have been adjusted differently. This makes it impossible to compare the strengths of cervical muscles in different groups from different studies. Therefore, the results for cervical muscle strength vary depending on the subject's position and the level of the fulcrum during testing.

In all directions of movement, isometric cervical extension and flexion strengths were significantly greater in wrestlers than in controls ($p < 0.001$). There were no significant differences between Greco-Roman wrestlers and free style wrestlers as regards isometric cervical muscle strength measurements. However, the Greco-Roman wrestlers appeared to have stronger cervical muscles than free style wrestlers when strength per kilogram body weight was compared between the two groups. Considering the non-significant differences in age, body weight, and height among the groups, the difference in cervical muscle performance between wrestlers and non-athletes is probably related to the long term specific training and competition program followed by wrestlers. The difference between Greco-Roman and free style wrestlers may be due to different training and competition related demands. In Greco-Roman wrestling, all techniques and manoeuvres are performed above the waist. Some manoeuvres in Greco-Roman wrestling such as salto (lifting, returning, and taking down an opponent to the mat from a rear standing position) demand very strong spinal and cervical muscle strength (fig 2). During taking down when the contestant's head hits the mat with force, the neck muscles may be eccentrically forced beyond normal limits. This manoeuvre may be dangerous and cause injury to the cervical vertebrae if the stability of the cervical spine is not maintained by active co-contraction of neck extensor and flexor muscles.

**Figure 2** The salto manoeuvre includes lifting, returning, and taking down an opponent to the mat.

Co-contraction of neck extensor and flexor muscles may also occur during cervical muscle strength measurements especially at the maximal level. This may influence the result of the ratio of isometric strength measurement of cervical flexor to isometric strength measurement of cervical extensor muscles. In this study, the order of testing was similar for all subjects. However, we believe that to examine the real effect of agonist muscle performance on antagonist muscle contraction at a maximal level, a separate randomised control study should be performed.

In this study, when we compared the ratio of the isometric strength of cervical flexor muscles to the isometric strength of cervical extensor muscles in different groups, we found that the ratio was higher in wrestlers than in non-athletes. This may indicate that wrestlers have better cervical spine stability than non-athletes because of much stronger flexor muscles. Similar results have been found in a comparison of cervical muscle strength between Finnish elite Greco-Roman wrestlers and non-sportsman.¹⁷

In several studies concerning the relationship between cervical pain and cervical muscle strength, it was revealed that weakness of the anterior and posterior cervical muscles contributed to pain persistence in patients suffering from chronic neck pain.^{18,19} Mayoux-Benhamou and Revel suggested that muscle strength insufficient for the demands of daily life, work, and sports activities may pose a great risk for neck pain.²⁰ The authors also suggested that dorsal neck muscle pain may be load related. Neck strength training has also been shown to improve chronic neck pain.²¹

Another factor related to cervical pain in wrestlers may be connected with the position of the head and neck. Harms-Ringdahl *et al* found that extreme bending of the cervical spine for a certain period of time produced neck pain in healthy subjects.²² It was concluded that such pain is derived more from the mechanical load on passive structures, such as the ligaments and joint capsules, than from sustained muscular activity.²³

What is already known on this topic

Cervical muscles and ligamentous structures are very susceptible to injury, particularly in sports such as wrestling. The risk of sustaining a neck injury is relatively higher in wrestling than in other sports.

The condition of the cervical muscles and the position of the cervical spine are often be associated with musculoskeletal problems in wrestlers. Thus, as regards prevention and therapeutic considerations, strengthening of cervical muscles may decrease neck pain. However, it remains to be shown if it also decreases the risk of neck injuries in wrestlers.

Isometric cervical muscle strength testing may be a useful technique to reveal muscle weakness in wrestlers. Special tests are needed in order to evaluate the ratio of the cervical muscle strength parameters. In comparison with the normal healthy population, this ratio may be an important indicator of the weakness of neck flexor or extensor muscles. The results of cervical muscle strength tests can be used to devise a course of exercise to specifically train weak muscle groups.

Strict refereeing can minimise the risk of serious injury. The referees should ensure that wrestlers observe the rules that prohibit dangerous manoeuvres, such as throws and twists directed at the head and neck. However, many wrestling manoeuvres can still cause great loading on the neck area. Imbalanced neck muscle strength can thus be assumed to be a risk factor in sports that put great strain on neck muscles. Wrestling inevitably increases the risk of strain injuries to the neck muscles; good strength of neck musculature is therefore essential to avoid serious trauma. This can be achieved only by special training directed at strengthening the cervical muscles. In order to improve training methods and safety, it may be useful to conduct special tests to discover possible muscle weaknesses.

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Competing interests: none declared

Figure 1 is reproduced with the consent of the subject

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What this study adds

The cervical muscle strength measurements of two groups of elite wrestlers (Greco-Roman and free style) and a group of control subjects were compared. Greco-Roman wrestlers appear to be stronger than free style wrestlers but the difference is not significant.

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COMMENTARY

This article is a welcome addition to the discussion about cervical muscle strength in sports populations and non-athletic subjects. Even though the sample is restricted, this study provides information about the relevance of specific training to enhance and maintain cervical strength. It increases our understanding of the relationships between body weight, physical training, and cervical strength and also puts forward training suggestions for athletes.

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